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To: Peter Lai

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RE: Comparison of the California Public Utilities Commission (CPUC) Energy Efficiency Avoided Cost Calculator ("E3 Calculator" for 2013), the California Energy Commission (CEC) Title 24 Building Code Time Dependent Valuation (TDV) factors (for 2013), and 'Site Energy' assessment

This memo presents a brief comparison of the value of electricity reductions as calculated using three methods currently used by the CPUC, CEC and the building community.

1. **CPUC EE avoided cost methodology**, embodied in the 'E3 Calculator', is applied in CPUC energy efficiency proceedings, as part of the investor-owned utilities (IOUs) requirements to demonstrate the cost-effectiveness of their proposed EE portfolios for Total Resource Cost (TRC), Program Administrator Cost (PAC), and Ratepayer Impact Measure (RIM) cost tests. The methodology was first developed in 2005 as part of a public CPUC proceeding (R.04-04-025). The electricity avoided costs are updated regularly, with this memo focusing on the draft avoided costs for 2013.
2. **CEC Title 24 Time-Dependent Valuation (TDV) methodology,** is applied as part of the adoption of new California building code requirements under Title 24. The methodology is used to assess the cost-effectiveness of new energy efficiency requirements in the building code using a modified Participant Cost Test (PCT), approximating a homeowner's bill savings. The TDV methodology was first developed in 2001-2003 for the 2005 Title 24 Standards Update and has been updated every three years with the new Title 24 code cycles. The 2013 TDV values are discussed herein.
3. **Site energy**, is a concept that originated in the building design community and evaluates the 'equivalent' BTUs of total energy usage on the site. Site energy is calculated as the total electricity consumption times 3412 BTUs/kWh plus the fossil fuel usage in BTUs. The value is not differentiated by time, cost, or adjusted for the source of the electric BTUs.

Both the CPUC's TRC and CEC's TDV approaches value on-peak energy savings more than off-peak energy savings. Both approaches account for the value of energy, capacity, transmission and distribution, ancillary services and greenhouse gas emissions, and value energy savings differently by hour and by location. This is in contrast to the site energy metric with values energy savings equally in all hours of the year and does not vary by location. However, there are also a number of key differences between the CPUC EE Avoided Cost methodology and the CEC Title 24 methodology, resulting in a generally higher avoided cost of electricity under the Title 24 TDV approach. The 2013 TDVs are

approximately 45% higher than the 2013 EE Avoided Costs for 15-year levelized values. The biggest contributors to the Title 24 TDVs being higher than the CPUC EE Avoided Costs are as follows:

- TDV uses a participant perspective that includes an adder to bring the avoided cost of energy up to retail rate levels;
- TDV uses a Societal discount rate that is lower than the utility weighted average cost of capital used for EE.

These differences, and other smaller differences, are described in the tables below.

Table 1. Basic Differences between CPUC EE Avoided Costs and CEC Title 24 Time-Dependent Valuation Factors

	CPUC EE Avoided Cost ('E3 Calculator')	Title 24 TDV Factors
Regions of analysis	Utility (PG&E, SDG&E, SCE, SGE) and climate zone combinations	16 climate zones
Purpose	Evaluate cost-effectiveness of IOU energy efficiency portfolios	Evaluate cost-effectiveness of new energy efficiency building codes
Cost test	Total Resource Cost test, based on wholesale electricity costs, requires no retail rate adjustment	Modified Participant Cost Test (hourly wholesale electricity costs grossed up to reach retail rate levels with a constant 'adder')
Discount rate	Each utility's WACC (e.g.: 7.66% nominal for PG&E)	Societal discount rate (3% real or ~5% nominal).
Measure life	Varies by measure Expected Useful Life (EUL)	15-years (non-res) and either 30-years or 15-years (res) depending on the measure (shell is 30 years)
Capacity costs	Calculated as the difference between the cost of a combustion turbine (CT) and the margins that CT could earn from the energy markets. Based on 2005 through 2010 historical market data.	Calculated as the difference between the cost of a combustion turbine (CT) and the margins that CT could earn from the energy markets. Based on market simulations for 2012 and 2020.
T&D capacity cost allocations	T&D costs allocated to hours based on CTZRV2 TMY weather files.	T&D costs allocated to hours based on CTZ2010 TMY weather files.

While there are differences between the CPUC EE avoided cost methodology and the CEC Title 24 TDV methodology, they are much more similar to each other than 'site energy.' Relative to the CPUC EE avoided cost and CEC Title 24 TDV, the use of site energy undervalues electricity savings (and on-site distributed renewable generation) relative to natural gas savings by the order of approximately 3 to 1, because the energy losses associated with generating and transmitting electric power from the grid are ignored. In other building processes, such as Energy Star rating and building standard process 'site energy' is converted instead to 'source energy' by multiplying a factor that reflects the BTUs combusted at the powerplant and losses to deliver a BTU of electricity to the customer. The factor to convert from site energy to source energy is approximately 3. This is a partial improvement, but source energy still

does not capture the value of reducing energy use during peak demand hours, as captured in the CPUC EE avoided cost and CEC T24 TDV methods.

The following table shows a comparison of the 2013 EE Avoided Costs and the 2013 TDV values expressed as $/MWh. For purposes of comparison, both the EE avoided cost and the TDV values are calculated assuming a 15-year measure life in PG&E climate zone 12. (The comparison does not vary much by climate zone.) In addition, the TDV values have been expressed in $/MWh[1]. The comparison shows that the 2013 TDV values are higher, particularly in the off-peak period, and are 45% higher on an annual average basis.

Table 2. Summary Comparison of CPUC EE Avoided Costs and CEC TDV Values

Period	Average of EE Levelized $/MWh	Average of TDV Levelized $/MWh	TDV % Increase above EE Costs
Summer Peak	$ 342.30	$ 290.74	-15%
Summer Partial	$ 142.47	$ 177.32	24%
Summer Off	$ 77.25	$ 159.16	106%
Winter Partial	$ 99.01	$ 145.37	47%
Winter Off	$ 80.51	$ 134.88	68%
Annual Average	**$ 112.41**	**$ 162.55**	**45%**
Maximum	$ 12,016.10	$ 1,873.99	-84%
Minimum	$ 9.95	$ 71.40	618%

The following two charts show a comparison of the same levelized values for the year in chronological and price duration order. In addition, the equivalent 'site energy' value is drawn on the graph using the CEC T24 conversion of $/Btu. Overall, the results show that both the CPUC's TRC methodology and the CEC's TDV methodology both value on-peak energy savings more than off-peak savings, and that both the TRC and TDV approaches result in a higher value for energy efficiency than the 'site energy' methodology.

[1] Note that the TDV values, when used for Title 24 Compliance estimates, are expressed as kBtu/kWh and kBtu/therm. These values are converted from $/kWh to kBtu/kWh and $/therm to kBtu/therm by dividing by a constant factor (0.084363 $/kBtu for 15-year measures, 0.164171 $/kBtu for 30-year residential measures, and 0.145972 $/kBtu for 30-year non-residential measures).

Figure 1. Chronological Comparison of EE, TDV, and Site Energy Values

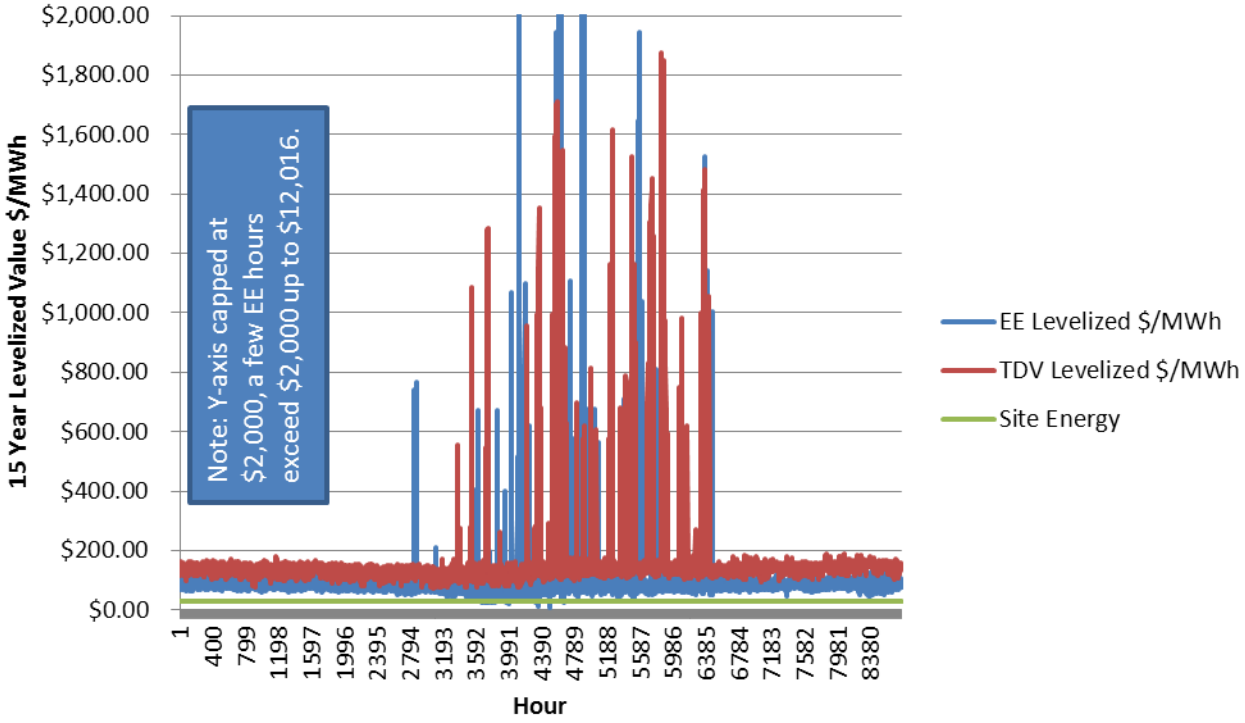
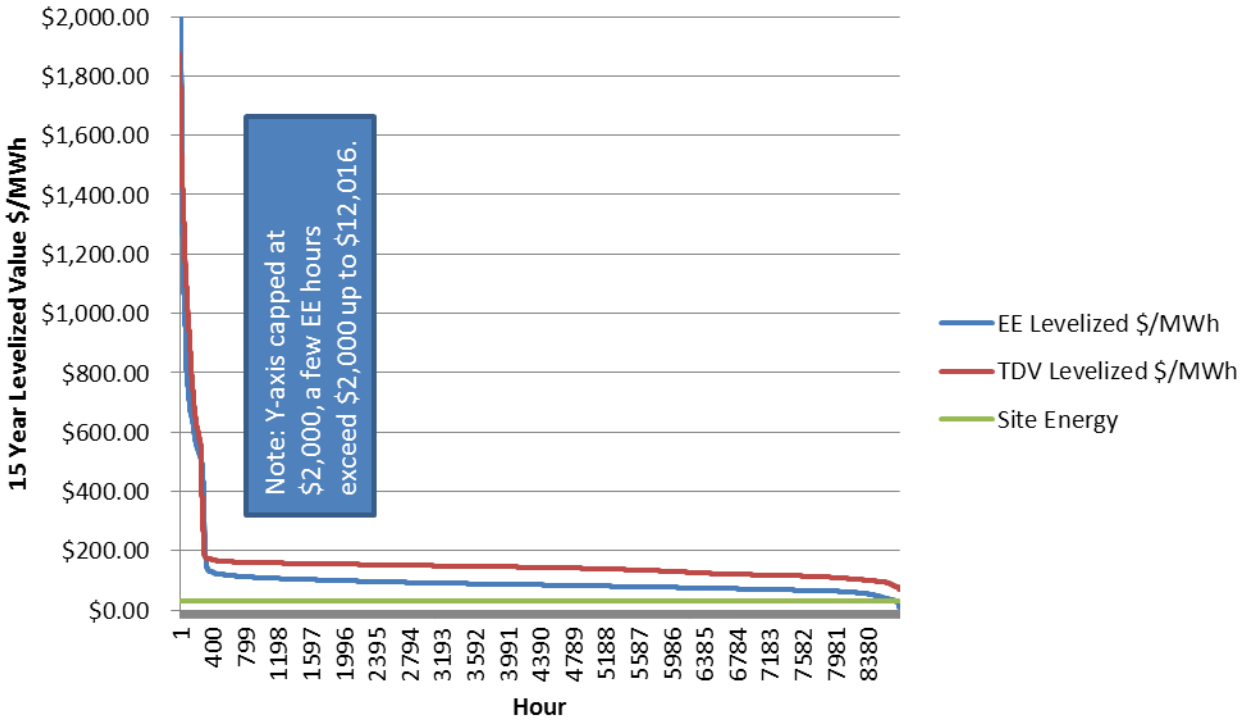


Figure 2: Price Duration Comparison of EE, TDV, and Site Energy Values



The following two charts show 3 peak days in July by component of the TRC avoided cost and the TDV values. The EE costs demonstrate more "peakiness" for both generation capacity and T&D capacity. This higher peakiness for EE results in avoided costs that are 15% higher than TDV in the summer on-peak overall.

Figure 3: Disaggregated Levelized EE Costs for Three Consecutive Days

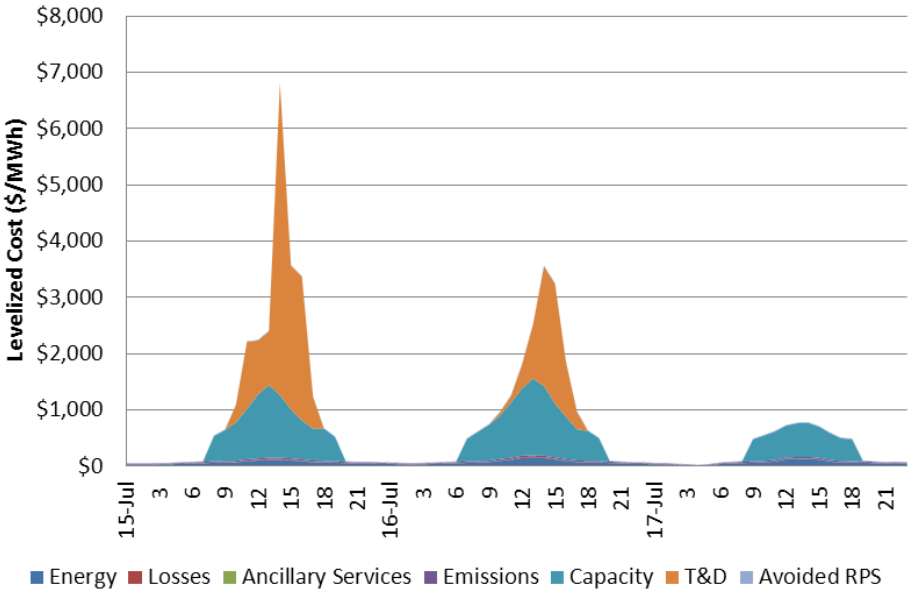
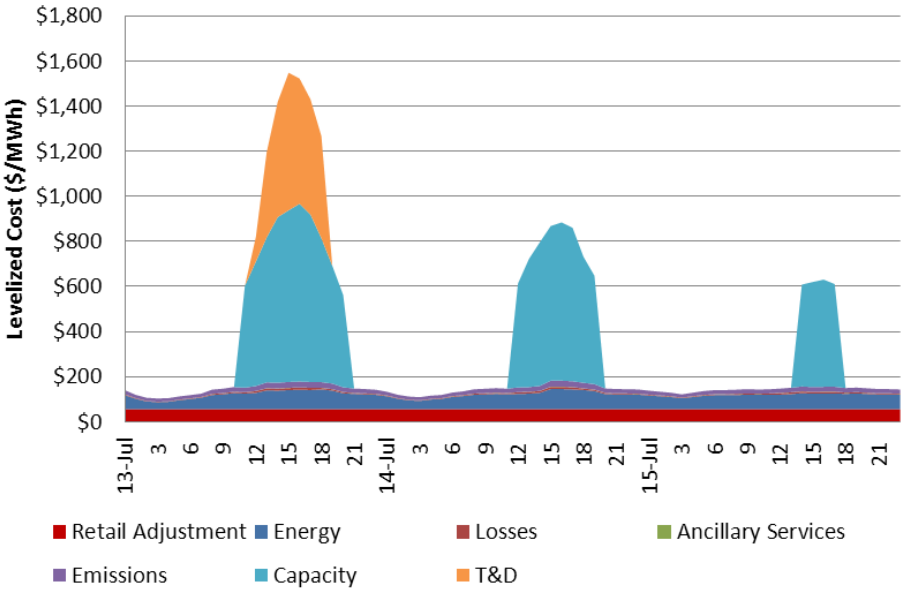


Figure 4. Disaggregated Levelized TDV Costs for Three Consecutive Days



Note that the charts are indicative of the hourly variations from each methodology. The costs for a particular date cannot be directly compared because of different energy market datasets and hourly weather files used to develop each set of costs.

The next two charts show the same avoided costs for the July days with a truncated vertical axis at $200/MWh. The new axes reveal the peakiness of the EE energy costs and the effect of the TDV retail rate adder. The retail rate adder increases the TDV avoided costs by $55.74/MWh for all hours and accounts for 34% of the total TDV levelized avoided cost.

Figure 5. Disaggregated EE Costs for Three Days– Truncated Axis

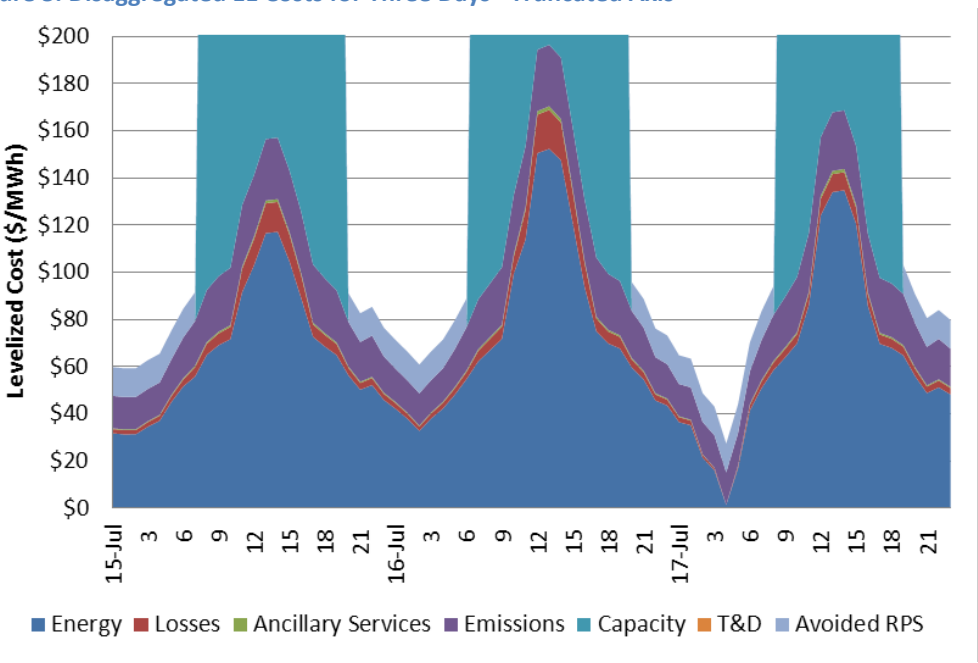
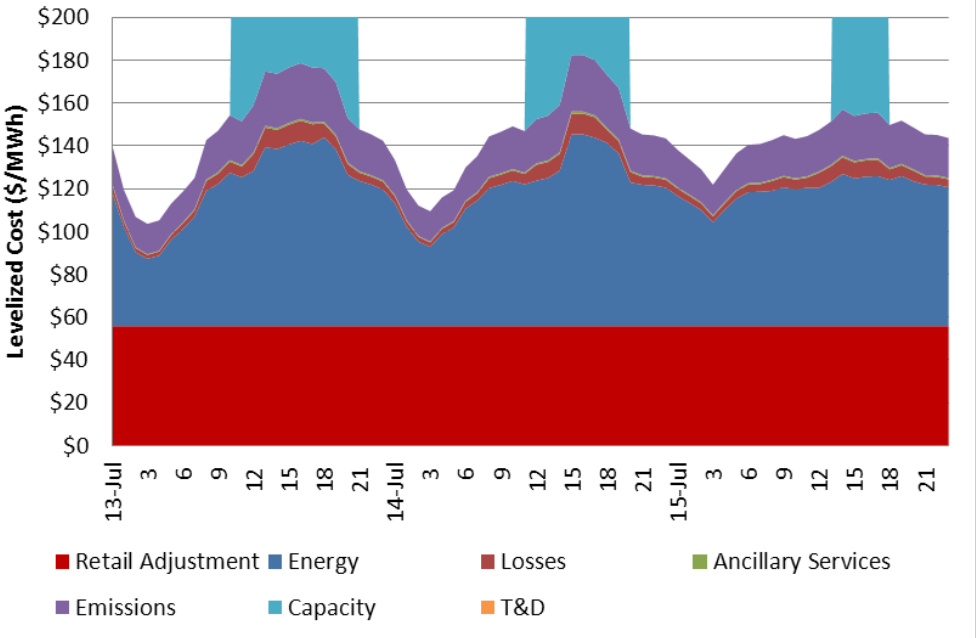


Figure 6. Disaggregated TDV Costs for Three Days– Truncated Axis



In addition to the retail rate adder, the use of a lower (social) discount rate for TDV can result in relatively higher electricity avoided costs compared to EE. To see the effect of the lower discount rate, the table below calculates EE levelized and net present value (NPV) costs for EE using the current 7.66% nominal discount rate for PG&E and the 5.06% nominal discount rate used for TDV.

Table 3. Impact of the discount rate on the levelized and net present value avoided cost a 15-year energy efficiency measure

Discount Rate (nominal)	7.66%	5.06%	% Increase
Levelized EE Cost ($/MWh)	$112.41	$113.50	1.0%
NPV EE Cost ($ over 15 yrs)	$1,187.09	$1,395.62	17.6%

The table shows that the annual levelized EE values over the 15-year measure life would only increase by 1% with the lower discount rate. This outcome highlights the fact that the choice of discount rates does not significantly change the avoided costs themselves. What the discount rate does affect is the net present value of the lifecycle avoided cost savings. The table shows that the NPV value of a one MWh reduction that lasts for 15 years would increase from $1187 to $1395 (over 17%) when the lower discount rate is used.

Additional, less influential, differences between the 2013 CPUC EE Avoided Costs, the 2013 TDVs are detailed in the table below.

Table 4. Additional differences between the CPUC EE Avoided Costs and 2013 Title 24 TDV factors

	CPUC EE Avoided Cost ('E3 Calculator')	2013 Title 24 TDV factors
Year developed	2011	2010
Retail rate adjustment	None	Higher forecast of statewide retail rates based on compliance with 33% RES and AB 32, same forecast applied to all zones
Market price shape	California 2010 day ahead market prices	CEC production simulation dispatch model for years 2012 and 2020. Price shapes are correlated with the climate zone weather files. The 2020 runs assume statewide achievements of the 33% Renewable Electricity Standard, so the underlying energy price reflects a different generation mix.
Cost and performance of a CCGT	2009 Market Price Referent	None. Energy market prices are forecasted based on a combination of market forwards through 2014 and a long-run forecast of California gas prices through 2040.

T&D Avoided Costs	General Rate Case filings from 2009 for SCE & SDG&E, and 2011 GRC Application for PG&E. The statewide sales weighted average is used for each climate zone. Costs allocated to hours using the same methodology as the TDV methodology, but with CTZRV2 TMY weather files, and no winter allocations.	General Rate Case filings from 2009 for PG&E, SCE & SDG&E, then the statewide sales weighted average is used for each climate zone. Costs allocated to hours using updated CTZ2010 TMY weather files.
Ancillary Services (A/S)	According to the CAISO's April 2011 Annual Report on Market Issues and Performance , CT A/S revenues from 2008 through 2010 averaged 7.6% of the CT energy market revenue. E3 uses this figure to assess the value of avoided A/S procurement in each hour.	Based on 2010 CAISO MRTU market levels. Load reduction (e.g efficiency) is only credited with spinning and non-spinning reserves.
Avoided renewable purchases adder	This RPS adder reflects the fact that as energy usage declines, the amount of utility renewable purchases required to meet the RPS goals also declines. Since the cost of renewable energy is higher than the forecasted cost of wholesale energy and capacity market purchases, energy reductions provide some value above the wholesale energy and capacity markets	None

For more details on the estimations for each component of the EE Avoided Cost see http://www.ethree.com/CPUC/E3_Avoided_Costs_Final.pdf

The calculation of the 2013 TDV factors and the methodology reports can be found at http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/

The powerpoint description of the 2013 TDV values can be found at http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2010-11-16_workshop/presentations/04-05_E3-Economics.pdf